CHAPTER 2— NIOSH Construction Program Overview

This chapter provides important background information and context for reviewing the NIOSH Construction Program. It begins with a short overview of the construction sector and a history of the program, then reviews key features of how the program operates. It describes strategic planning and program partnerships.

2.1 Construction Sector Overview

Construction is a large, dynamic and complex industry sector that plays an important role in the U.S. economy. The value of construction put in place in 2005 was estimated at $1.1 trillion dollars [Census Bureau, 2005]. Construction workers and employers build our roads, houses, and workplaces and repair and maintain our nation's physical infrastructure. This work includes many inherently hazardous tasks and conditions such as work at height, excavations, noise, dust, power tools and equipment, confined spaces, and electricity. The industry is divided into three subsectors (See Table 2.1) reflecting several substantial differences in the types of equipment, work force skills, underlying production functions and other inputs required by various construction establishments. The *Construction of Buildings* subsector comprises establishments of the general contractor type and operative builders involved in the construction of residential and commercial buildings. The *Heavy and Civil Engineering Construction* subsector includes establishments involved in the construction of engineering projects such as roads and bridges. The *Specialty Trade Contractors* subsector comprises establishments engaged in specialty trade activities generally needed in the construction of all types of buildings. The three subsectors are further divided into 28 additional categories under the North American Industry Classification System (NAICS).

Table 2.1. List of Construction Subsectors

Code*	Construction Subsector	Employment 2005†	Rates, 2004‡	
			Injury	Illness
236	Construction of Buildings	1,727,200	5.5	13.4
237	Heavy and Civil Engineering Construction	974,800	5.8	16.2
238	Specialty Trade Contractors	4,714,000	6.6	13.4
23	Construction Sector	7,416,000	6.2	13.8

* North American Industry Classification System (NAICS)
† excludes self-employed and publicly employed workers
‡ injury rates per 100 employees/yr; illness rates per 10,000 employees/yr

In addition to construction employers, there are an additional 2.5 million self-employed "one person" businesses without other paid employees and these are not included in Table 2.1 [Census Bureau, 2005]. Adding in these self-employed individuals along with public employees performing construction gives an estimated total population of 9.9 million persons that can be considered to make up the construction sector.

Construction businesses encompass large sophisticated multinational firms engaged in commercial and industrial construction along with numerous small and medium sized firms. Fully 81% of the construction businesses with paid employees have fewer than 10 employees, and these firms employ 24% of all construction employees. Large establishments with 500 or more employees represent less than 0.1% of all construction firms and employ 6.8% of construction employees [Census Bureau, 2005].

The Bureau of Labor Statistics (BLS) identifies 20 different construction trade occupations and these occupations are reflected in many of the trade unions and trade associations that represent the industry. Construction workers are typically younger than the national labor force, but the average age in the industry has been increasing. Most construction workers are aged 25–54 (75.4%), male (90.3%), and white (90.8%). The industry is undergoing demographic change via inflow of immigrant workers. One study estimated that unauthorized [1]immigrant workers represented 14% of the construction workforce in 2005 in comparison to a national total of 4.9% of the civilian labor force [Passel 2006].

There are many characteristics that make the construction industry unique from most other industries. Many relate to how the industry operates or how the work is performed. The industry is diverse and varies widely in scale. Construction work can range from short term residential repairs to maintenance and renovation of existing structures to major decade-long infrastructure projects involving scores of individual construction firms. The Construction Program issues a “Chart Book” that characterizes the complexity of the industry in detail, and a copy is provided along with the evidence package.

Injuries and Illnesses

Injury and illness rates provide a benchmark on the success of industry occupational safety and health strategies. Those portions of industry with the highest rates reflect a combination of factors such as inherent hazards and need for additional protection efforts. Using 2004 data, Table 2.1 shows those subsectors of the construction industry and their average injury and illness rates. Fatal injuries are an important concern, and the construction industry lost more workers to traumatic injury death than any other major industrial sector during this time period with 1,186 deaths in 2005, 21% of all occupational fatalities in that year. Construction has the fourth highest rate of death by injury: 11.0 deaths per 100,000 workers. Only agriculture, mining, and transportation experience higher rates as shown in Figure 2.1. The leading causes of death among construction workers are falls from elevations, motor vehicle crashes, electrocutions, machines, and struck by falling objects[2]

[1] The authors used the term “unauthorized” to refer to undocumented immigrant workers
[2] http://www.cdc.gov/niosh/injury/traumastruct.html

Fatal work injuries involving construction laborers accounted for nearly one out of every four private construction fatalities in both 2004 and 2005 (Figure 2.2).[3] In 2001, BLS reported that the construction industry experienced 481,400 nonfatal injuries and illnesses at a rate of 7.9 per 100 full-time workers in the industry.[4]

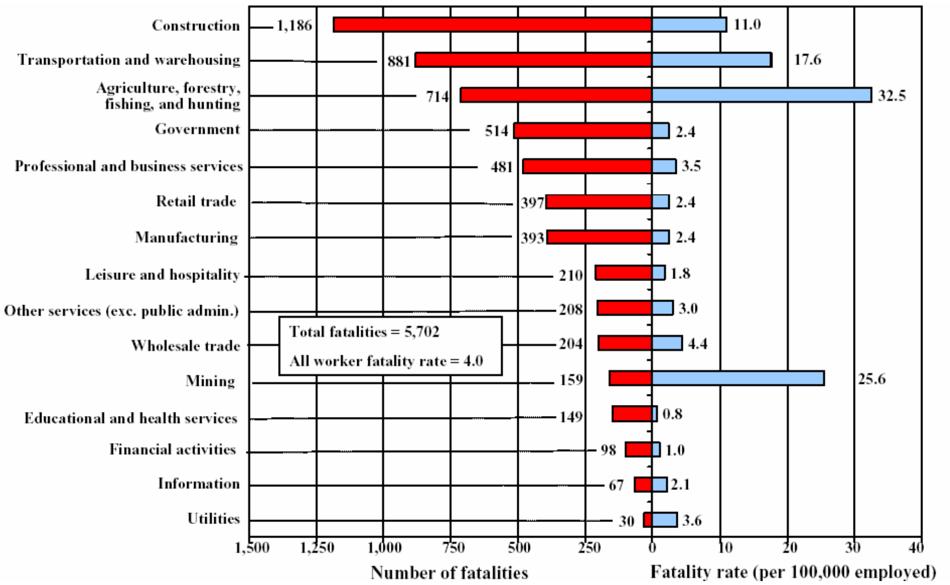

Figure 2.1. Number and rate of fatal occupational injuries by private industry sector, 2005

Rate = (Fatal work injuries/Employment) x 100,000. Employment data based on the 2005 Current Population Survey (CPS) and Department of Defense (DOD) figures. SOURCE: US Department of Labor, Bureau of Labor Statistics, Current Population Survey, Census of Fatal Occupational Injuries, and US Department of Defense, 2005.

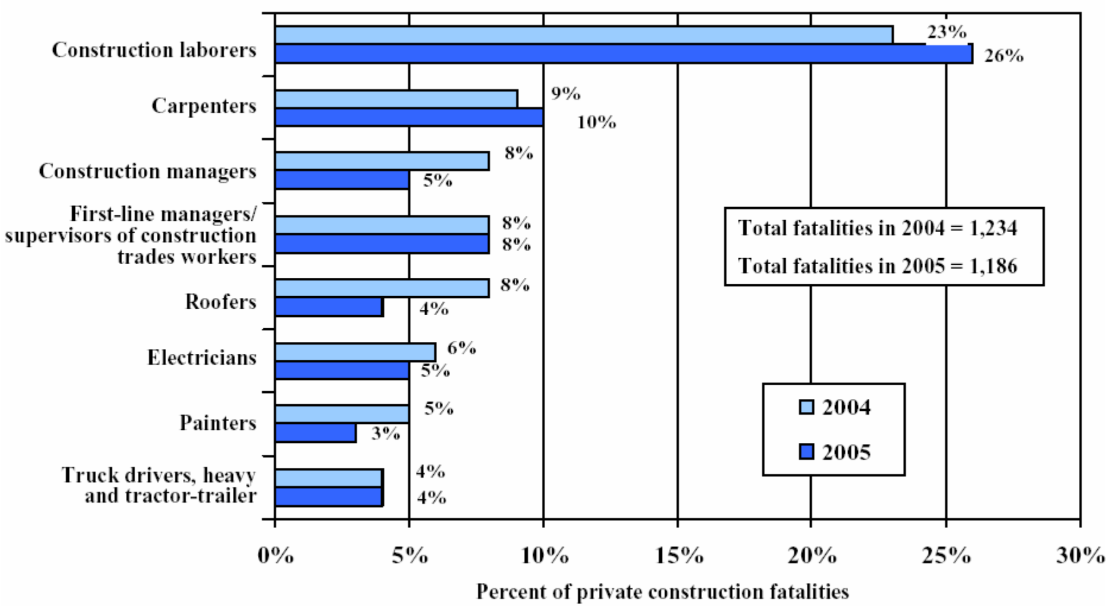

Figure 2.2. Distribution of fatalities across occupations in the private construction industry, 2004-2005

NOTE: Percentages do not add to 100% because not all categories are shown.

SOURCE: US Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2005.

[3] http://www.bls.gov/iif/oshwc/cfoi/cfch0004.pdf

[4] http://www2a.cdc.gov/niosh-Chartbook/ch4/ch4-2.asp

Table 2.2 shows the ranking of severity of injuries by days off work by subsector in the construction industry in the United States. Specialty trade contractors lead the industry with the most severe injuries with 258.7 cases per 10,000 workers with days off-of-work as a result of an injury or illness. Table 2.2 also shows above average rates of injury and illness for 1 day away from work for the construction of building subsector and 21 to 30 days away from work for the heavy and civil engineering construction subsector.

Table 2.2 Incidence Rates of Injuries and Illnesses, per 10,000 Workers per Year, 2004

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Number of days away from work	Private industry	Construction	Construction Subsectors		
			Construction of buildings	Heavy & Civil Engineering Construction	Specialty Trade Contractors
1 day	20.3	32.8	41.1	18.3	32.9
2 days	16.2	24.7	22.4	18.4	26.9
3-5 days	26.0	41.6	32.6	38.8	45.6
6-10 days	17.9	29.8	26.7	26.7	31.6
11-20 days	16.1	28.8	20.2	25.5	32.7
21-30 days	9.6	17.0	15.8	17.2	17.4
>30 days	35.3	69.1	62.1	68.2	71.8
Total	141.3	243.7	220.8	213	258.7

Several health hazards and associated diseases among construction workers have been recognized. These include fume fever (metal, polymer), cadmium poisoning, carbon monoxide poisoning, acute inhalation injury (NO_2, ozone, phosgene), manganese poisoning, asbestosis, silicosis, acute solvent syndrome, peripheral neuropathy, alkaline burns, photoirritant dermatitis, lead poisoning, chloracne, allergic contact dermatitis, chronic obstructive pulmonary disease, dry skin or irritation, irritant contact dermatitis, occupational asthma, and hypersensitivity pneumonitis.

2.2 NIOSH Construction Program Program History

NIOSH research activities on construction have evolved over time. A short history divided into four phases provides context and a foundation for evaluating the current state of the program. A more comprehensive version is provided in Appendix 2.1.

1970 - 1990 – Period 1 - Individual projects and activities

NIOSH did not organize research by industry categories during its early years and did not have a construction program per se. NIOSH did address issues relevant for construction via individual projects and activities. For example, construction was included in early surveillance projects such as the National Occupational Hazard Survey (NOHS) and National Occupational Exposure Survey (NOES) and the National Traumatic Occupational Fatalities (NTOF) surveillance program. Projects addressing construction topics such as asphalt fumes and silica were initiated during this period. Grants and contracts were also used to support a number of studies, such as epidemiological studies of risks in the painters' trades, research on silicosis and its association with sandblasting, and safety profiles for specific construction activities. Various NIOSH products addressed topics relevant for construction. For example, criteria documents and recommended standards were developed on noise, ultraviolet radiation, elevated work stations, crystalline silica, asphalt fumes, construction confined spaces, excavation, and occupational exposure to hand-arm vibration. NIOSH also provided testimony and comments to OSHA on ten construction-related proposed rules.

NIOSH Fatality Assessment and Control Evaluation (FACE) activities, initiated in 1983 to investigate fatal injuries, and NTOF (started in 1984) provided important inputs to construction research. Other important activities include SENSOR (Sentinel Event Notification Systems for Occupational Risk) and ABLES (Adult Blood Lead Epidemiology and Surveillance). SENSOR is a program of state-based disease or injury condition-specific surveillance and intervention efforts, and ABLES is a program to track state-based laboratory-reported blood lead levels (BLLs) in adults. Both were begun in 1987.

In 1989, NIOSH sponsored a National Forum on Construction Safety and Health in Pittsburgh hosted by the Center of Excellence in Construction Safety of West Virginia University. The forum identified three problems requiring action: (1) education was needed at every level of construction from owners to workers, (2) the inclusion of safety and health protections in construction contracts, and (3) the need to focus on primary injury exposures.

1990- 1995 – Period 2 - Creation of the NIOSH Construction Program

Increasing stakeholder interest and concern about construction safety and health issues, especially from construction trade unions, played an important part in encouraging Congressional hearings in 1990 about the level of resources and programs targeting construction.[5] NIOSH expenditures on construction research could only be estimated and were lower than expenditures for sectors such as manufacturing and mining. The NIOSH Construction Program was launched in 1990 when Congress provided funding ($1 million) and authorized NIOSH to *"develop a comprehensive prevention **program** directed at health problems affecting construction workers by expanding existing NIOSH activities in areas of surveillance, research and intervention."*

NIOSH took a number of important steps during the following years to lay a solid foundation for the program:

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[5] Representatives from the Laborers Health and Safety Fund of North America (LHSFNA) calculated that while the fatal injury rate for construction workers was more than three times higher than for manufacturing workers that U. S. government research spending was $0.08 per construction worker vs. $2.16 per manufacturing worker [NIOSH 1994]

-As a first step, NIOSH co-sponsored a 1990 “National Conference on Construction Safety and Health” with the Northwest Center for Occupational Health and Safety in Seattle to identify leading causes of injuries and illnesses among construction workers and to build relationships with construction stakeholders and researchers interested in construction issues. A broad range of recommendations were made, including the need for research on the impact of interventions in reducing injuries and diseases.

-In 1990, Requests for Applications (RFAs) were issued for two cooperative agreements to encourage extramural research in construction. Half of the appropriated funding from Congress was used for cooperative agreements. Two were for state demonstration projects and two were to research work-related risks [Myers 1995]. Extramural research has played an important role in the Construction Program ever since these early steps.

-A NIOSH-wide Construction Task Group was established to prepare a plan and budget for construction research. Because NIOSH is organized into divisions that focus on a type of health outcome or research or service category, there was no logical division home for the program. Construction issues were viewed as encompassing all NIOSH divisions. The task group produced a *Construction Safety and Health Initiative* document to guide efforts in 1992. It included research activity and capacity building goals related to surveillance, research, and intervention.

Congress provided budget increases (varying from $1.9 to $3.9 million) each year for the next four years along with specific language to guide capacity building and provide direction and focus. Table 2.5 describes the Congressional language highlights and Construction Program responses for the years 1990 to 1995.

The Construction Program supported a *National Conference on Ergonomics, Safety, and Health in Construction – Setting the Agenda and Creating a Coalition* in 1993. The conference was organized by CPWR and supported by the Building and Construction Trades Department (BCTD) of the AFL-CIO, OSHA, U.S. Department of Energy, the American Industrial Hygiene Association, the American Public Health Association, the National Constructors Association, the National Erectors Association, the National Safety Council, the Society for Occupational and Environmental Health, and the ANSI A-10 Committee on Safety in Construction and Demolition. It also involved participation by four international construction agencies and associations.[6] This meeting identified 15 critical hazards that should be controlled on each construction work site. It also provided recommendations for a national program:

- build a national coalition for construction safety and health

[6] These were Bau-Berufsgenossenschaft (Germany); Bygghalsan (Sweden); Construction Safety Association of Ontario (Canada) and Stichting Arbouw (Netherlands)

- strengthen national policies
- increase safety and health programs on job sites
- develop workforce skills with safety and health training and certification
- conduct research

By 1994, the Construction Program budget was $11.8 million[7] and NIOSH had greatly expanded its intramural and extramural research program. Extramural activity included state demonstration projects and several cooperative agreements and research grants.

Table 2.5. – Congressional Direction and funding and NIOSH response during program start-up years 1990-1995

Year	Congressional Charge and funding	NIOSH actions in response
1990	**$1 million** Develop a comprehensive prevention program directed at health problems affecting construction workers by expanding existing NIOSH activities in areas of surveillance, research, and intervention.	Half of appropriation used for intramural research and half for extramural programs: 2 cooperative agreements for state demonstration projects and 2 for identification, evaluation and control of work-related risks
1991	**$1.9 million increase** Expand the construction safety and health program and include the development of surveillance data to identify and monitor emerging hazards in the construction industry, conducting research regarding fatalities and injuries among construction workers, and establishing training programs and demonstration projects to disseminate information concerning the prevention of injuries and illnesses in the construction industry	Expansion of intramural program and augmentation of existing cooperative agreements and addition of two new agreements
1992	**$2.55 million increase** Examine work practices and workers' compensation records and establish training programs and demonstration projects concluding with the eventual development of comprehensive intervention and prevention plans	Issuance of 2 more RFA's for cooperative agreements on reducing musculoskeletal disorders among construction workers
1993	**$3.97 million increase** Increase intramural research capacity; expand the Health Hazard Evaluation Program; establish research centers for construction safety and health to nonprofit universities to complement intramural programs; and develop community based intervention projects aimed at the prevention of construction-related diseases and disabilities	Expansion of intramural program projects, augmentation of HHE program for construction workers, and issuance of RFA for research grants in construction
1994	**$2.65 million increase** Provide research grants at nonprofit universities and other nonprofit institutions directed at generating prevention initiatives. Establish a new 5 –year cooperative agreement with the construction trades to develop a center for prevention-oriented strategies and programs. Allow for training in the construction industry for the removal of lead	Additional budget resources were dedicated to the extramural program. An additional research grant RFA was issued, along with a new cooperative agreement dedicated to intervention research, and two lead abatement training grants.
1995	**No increase** Activities in surveillance and musculoskeletal disorders should be continued at current levels.	Issuance of an RFA to establish a "Prevention Center for Construction Safety and Health."

[1] Representatives from the Laborers Health and Safety Fund of North America (LHSFNA) calculated that while the fatal injury rate for construction workers was more than three times higher than for manufacturing workers that U. S. government research spending was $0.08 per construction worker vs. $2.16 per manufacturing worker [NIOSH 1994]

[7] The Congressional Conference action amount was $12,158,000 in 1994. The end allocation to NIOSH was $11,868,404 [Myers, 1995, p6]

Congressional language in 1994 directed NIOSH to establish *"a new 5-year cooperative agreement with the construction trades to develop a center for prevention-oriented strategies and programs"* which led to an RFA for a "Prevention Center for Occupational Safety and Health in the Construction Industry". The resulting competitive award went to the CPWR and a consortium CPWR developed with ten academic institutions.

NIOSH awarded eight cooperative agreements and eight research grants under this initiative. Three of the agreements aimed to demonstrate model safety programs that could be sustained following the award period. Another agreement with CPWR featured collaboration with 15 construction unions and employers of those union's members.

Research grants during this period addressed several issues including: (1) lead-exposed workers, (2) collapse of formwork and shoring, (3) overexertion injuries, (4) airborne hazards, (5) injury prediction models, (6) respiratory diseases among carpenters, (7) an exposure matrix for painters.

NIOSH intramural projects addressed the surveillance, evaluation, and control of exposures related to noise, musculoskeletal stressors, lead, asphalt fumes, asbestos substitutes, silica sand, heat stress, falls, and falling objects. In addition, several proportional mortality studies were launched in cooperation with CPWR for different construction trades. NIOSH responded to a large increase in requests for Health Hazard Evaluations (HHEs) at construction sites Sixty requests were filed in 1993. For all previous years, the total was 40. FACE instigations, and technical inquiries to NIOSH regarding construction workers also increased.

The Construction Program published, *1994 FACT BOOK: National Program on Occupational Safety and Health,* the first compendium to describe Construction Program activities. It provided short descriptions of 51 projects, including 35 intramural projects, 8 cooperative agreements and 8 research grants [NIOSH 1994]. A Symposium was held in 1994 to bring together NIOSH and grantee investigators to exchange research findings and to highlight progress.

Beginning in 1995, the Congress directed that Construction Program activities be continued "at current levels." Similar appropriations language has been provided each year since then. Congressional language has also included concerns about the number and rate of construction fatalities in recent language accompanying appropriations details.

The Construction Program supported and co-sponsored with the National Construction Center a "Second National Conference on Ergonomics, Safety, and Health in Construction" in 1995. The conference was planned in conjunction with a committee formed from the BCTD and seven contractor associations. The committee's purpose was to address construction safety and health issues after the 1993 national conference. A total of 37 organizations co-sponsored the meeting. The conference aimed to mesh the protection of construction workers from occupational disease and injury with concerns about the continued viability of the industry and then set a national agenda for construction safety and health. The conference addressed workers' compensation, worker certification on safety topics, surveillance, exposure measurement, limited duty, economics, and demonstration projects. Ergonomics was stressed because of the prevalence and cost of musculoskeletal disorders among construction workers. The conference identified 15 main hazards and focused on four areas where safety and health interventions were needed:

- work site organization and management
- new technologies and work practices
- training of workers and supervisors
- data collection and performance evaluation

The meeting was an important vehicle for transferring research findings to construction stakeholders, for fostering partnerships, for identifying research gaps, priorities, and opportunities, and for moving research into practice. It also established best practice benchmarks based on evidence from high performance nations and segments in the United States.

In 1995, the NIOSH Director requested that an external review be performed for the Construction Program. The outside panel selected to perform the evaluation focused on program management and coordination and research directions. The results of the review are described in the next section.

By 1995, the Construction Program had an $11.8 million budget, with intramural projects originating in every NIOSH division. It included a multi-disciplinary "National Construction Center" cooperative agreement with CPWR to build capacity and demonstrate effective surveillance and intervention mechanisms. The cooperative agreement mechanism allowed close collaboration between NIOSH intramural researchers and CPWR in-house researchers, the university-based research consortium, and with construction industry unions and contractor organizations. In addition, large national conferences had for the first time brought together researchers and construction stakeholders to discuss research needs and priorities to guide research and to guide other steps needed for improvements in industry performance. Ongoing and completed research resulted in numerous peer-reviewed publications. An Occupational Medicine State of the Art Review was published on Construction Safety and Health in 1995. It was edited by Construction Center researchers and included 15 chapters by various Construction Program and other researchers. [Ringen et al.,1995].

Strategic Planning during this period (1990-1995)

The major strategic inputs during this period were the Congressional mandates and directives (described in Table 2.5) combined with construction stakeholder input obtained from national conferences. Some inputs addressed capacity-building recommendations (e.g. 1991 Congressional language directing NIOSH to “establish training programs and demonstration projects to disseminate information concerning the prevention of injuries and illnesses in the construction industry”) and others addressed specific hazards or approaches (e.g. 1991 Congressional language directing NIOSH to conduct research regarding fatalities and injuries among construction workers).

In 1992, NIOSH leadership, working with a NIOSH-wide Construction Task Group, used this input along with researcher inputs to develop construction safety and health goals and objectives to guide the Construction Program. The plan included goals related to surveillance, research, and intervention development. It also identified construction workers as special population targets for national fatal and non fatal injury goals under the U.S. Department of Health and Human Services Healthy People 2000 national health objectives. The plan provided an important blueprint for Construction Program efforts, envisioned collaboration with other agencies, and recognized that the construction industry, including both labor and management, was an essential partner in providing input on research and intervention needs.

The plan directed intramural NIOSH research for 1992 and 1993. The goals and objectives were communicated to extramural researchers via guidance language included in the text of RFAs published during these years. The plan served to integrate stakeholder concerns and direct research during a period of tremendous growth of the program, and it provided an important planning foundation for future efforts.

1996 - 2004 – Period 3 - National Occupational Research Agenda (NORA) and External Review

Construction was suggested as a top priority candidate by two of five working groups during the NORA process that began in 1996 (see Chapter 1). However, a cross-cutting approach to topics was taken [Rosenstock et al 1998]. Nevertheless, the importance of focusing research on high risk sectors was recognized, resulting in the use of a matrix approach to track, manage, and report on the NORA-related research being performed in construction and other high risk sectors.

Another major development for the Construction Program during this period was responding to the recommendations coming out of the 1995 external review [Snell 1996]:

- Establish an overall management structure for the Construction Program to further develop and implement a long-term strategic plan for intramural and extramural funding.
- Review all research programs for scientific merit and for relevance to the construction industry.
- Promote effective internal and external communication between and among investigators studying similar tasks or hazards.
- Formulate a plan to disseminate effectively program results to customers and to enhance the visibility of NIOSH work to all outside groups, including the general public.
- Have available, as employees or consultants, persons experienced in construction.
- Enhance coordination with OSHA.
- Identify a limited number of measures by which to evaluate the effectiveness of the Construction Program.

In 1996, NIOSH formed a Construction Steering Committee (CSC) to implement the coordination and planning called for in the evaluation report. The CSC included a coordinator and a representative from each NIOSH division and lab. It began work to increase internal and external communication, and established a review process for proposed construction projects. The CSC also encouraged construction research through intramural funding of small scale feasibility studies, many of which were later developed into major projects, e.g., well drilling hazards.

Also in 1996, NIOSH and CPWR and its Construction Center consortium members held a program planning conference to review accomplishments from the first five years of the program, to discuss research needs and the results from the external review recommendations, to promote communication, and to identify some proposals for the future. The two-day meeting drew 140 participants from the construction industry, government, and academia.

In 1997, the Construction Program published a second *Construction Compendium* to describe ongoing research projects. Reflecting the importance of NORA, the 45 extramural and 74 intramural projects described in the compendium were organized by NORA priority research topics [NIOSH, 1997].

The first edition of *The Construction Chart Book* was published in 1997 by the Construction Center. It contained 102 charts providing descriptive statistics about the construction industry and its safety and health performance. A second edition was published by the Construction Center in 1998, and a third edition was published in 2002. By 2004, CPWR printed and distributed some 18,000 copies of the book, and thousands more were accessed via the web. The book served as the model for NIOSH's Chart Book on overall occupational safety and health.

The Construction Program and Center staff began collaborating to develop a web-based construction safety and health clearinghouse in 1999. The resulting Electronic Library of Construction Occupational Safety and Health (eLCOSH) was launched in 2000. This has become a primary resource for construction safety and health stakeholders (see Goal 4 in Chapter 3).

The Construction Center developed a standardized safety and health hazard awareness training program for construction workers, which was adopted by BCTD,AFL-CIO, international construction unions, and employers. This *Smart Mark* program was recognized by OSHA as a model training program for the industry; it has been incorporated into joint labor/management training centers nationally; over 4,000 building trades union instructors have been certified to deliver the training; and now over 50,000 construction workers are trained annually in the 10-hour program.

In 2001, Congress directed NIOSH to expand the Construction Program by appropriating funds for a three year grant to Purdue University. Following a peer-review application process, this led to the formation of a “Construction Safety Alliance” partnership project based out of the Purdue Division of Construction Engineering and Management.

The third Construction Compendium was published in 2002. It contained descriptions of 49 intramural and 67 extramural Construction Program projects [NIOSH, 2003].

The NIOSH Construction Program matured and entered a stable but flat funding period during these years. The program had put in place a capacity for surveillance and internal mechanisms to improve program management and had made a transition to development and diffusion of interventions.

Strategic Planning during this period (1996-2004)

The major strategic inputs during this period were the NIOSH-wide NORA priority topic areas and the external review recommendations. These inputs included capacity-building recommendations (e.g. the External Review Committee recommendation for the development of a management structure for the program to further develop and implement a long-term plan for intramural and extramural funding) to inputs about specific hazards and approaches.

NORA had an important impact on the NIOSH Construction Program because it superimposed 21 topic areas as primary priorities for all NIOSH supported research, including construction research. Because the NORA priorities included topics that were also highly relevant for construction, NORA did not inhibit construction research. However, because of the cross-cutting nature of the NORA priority research areas, it served to increase the proportion of projects where the primary focus was the NORA topic with construction a secondary consideration.

The Construction Program developed two mechanisms for communicating strategic planning priorities to stakeholders. First, the Construction Steering Committee prepared annual guidance for new construction projects which was disseminated along with NIOSH-wide guidance to internal NIOSH researchers and policy analysts during project planning season. Second, the CSC used expanded text in upcoming RFAs to communicate research needs and priorities to the extramural community.

Given the importance of the large Construction Center cooperative agreement to the Construction Program, the CSC prepared in advance to develop an approach and emphasis to include in the second Center RFA proposal. Building upon the surveillance foundation created by the first Construction Center RFA, the second RFA was structured to maintain and expand ongoing surveillance while generating new coordinated extramural research on construction interventions, information and technology transfer, and preventive systems research. The scope for interventions could include policies, regulations, education and training, government and private outreach programs, and control technology and new technology for preventing injury and work-related diseases. Because the 21 NORA topic areas were established as prominent nationwide priorities, submitters were asked to focus on NORA priority areas relevant to construction when responding to the request. The Construction Program provided additional guidance and specificity, especially for those more general NORA topics such as "Traumatic Injury". This RFA, issued and competed in 1999, led to a second five year competitively awarded cooperative agreement with CPWR and its university consortium that began in 2000.

The NIOSH Construction Program had begun a multi-phase process beginning in 1997 to assess progress and to identify construction research gaps to develop a long-term strategic plan in response to external review recommendations. A gaps analysis using the public health framework was performed over several years resulting in a "Research Activity Matrix" or RAM. The RAM listed and ranked 12 categories containing 58 different "Construction Outcomes, Conditions, and Overexposures." It portrayed existing research via 14 different research activity categories. The RAM provided a visual picture of NIOSH construction research and it was used to assist project planning by improving identification of high priority outcomes and their gaps. The CSC began to include the gap topics identified by the RAM in annual project planning guidance for development of new intramural research projects beginning in 1998.

The CSC shared the RAM with Construction Center researchers beginning in 2000 and incorporated the Construction Center projects into the RAM to get a more comprehensive picture of research gaps and opportunities. In addition, a workshop was held at the February 2000 Construction Safety Council

Conference to describe and discuss the preliminary list of construction outcomes, conditions, or overexposures needing additional research. Attendees were asked to provide their scores for whether each topic was of low, medium, or high priority. These results were used for considered and the RAM was then used to generate a list of high priority topics. The priority topics were organized into three categories: 1) health and injury outcomes, 2) chemical and physical exposure topics, and 3) approach and sector topics. These were listed in the 2002 *Construction Compendium*.

In 2001, the CSC began planning for the next five-year National Construction Center Cooperative Agreement. The Center RFA had resulted in projects that characterized hazards and developed and evaluated important construction interventions. But adoption of solutions by the industry had been uneven and uncertain, and gaps in understanding how to successfully diffuse effective interventions were recognized. The RFA stipulated that 20% of direct costs were to be directed to translation projects. Additional language was added to focus on measuring impact. The list of high priority topics was also included. Excerpts from the RFA are shown in Table 2.15

This RFA was competed and the CPWR consortium scored highest and was again awarded the National Construction Center cooperative agreement. Several individual projects submitted as components of other Center proposals also scored well and three projects from Virginia Tech and one from Purdue were also funded as part of this cycle.

Table 2.15. - Excerpts from 2003 Construction Center RFA: (emphasis added)
…. The emphasis of the Construction Centers should be on addressing priority occupational health and safety issues using a multi-disciplinary approach. Translation projects focus on the translation of extant knowledge (e.g. peer reviewed articles) into products or practices that meet construction customer needs so as to maximize the impact on industry practices. The NIOSH Construction Steering Committee has identified a number of priority topics in emerging areas of interest where research will most likely make a difference. These NIOSH identified topics can be grouped into three categories: • Health and injury outcome topics which target: 1. Leading types of fatal and non-fatal traumatic injuries in construction. 2. Low back injuries and other cumulative work-related musculoskeletal disorders among construction workers. 3. Occupational illness topics that focus on respiratory disease and hearing loss. Respiratory disease includes airways disease, asthma, chronic obstructive lung disease, and silicosis. • Chemical and physical exposure topics which target vibration, asphalt fumes, lead, and dust particles. • Approach and sector topics that target the following groups and issues within construction: 1. Small and self-employed contractors. 2. Special sub-populations at risk within construction such as Hispanic workers, day laborers, young workers, aging workers. 3. The role of design as a primary prevention tool for addressing construction hazards. 4. Addressing work organization in construction and improving understanding of how it affects health and safety. 5. Working with building owners and clients to promote and evaluate construction best practices. 6. Leveraging promising approaches from related high risk sectors such as agriculture and mining into construction. Other topics relevant to construction health and safety are also appropriate for this RFA. The significance of a project and relevance to the elimination of hazards in the construction industry must be fully described and developed in the application.

2005 to 2007 – Current Period - Strategic Goals, Research to Practice, and NORA 2

In the last few years, new approaches to government planning such as OMB's Program Assessment Rating Tool (PART) placed increased emphasis on strategic planning, independent expert evaluation of research programs, and program performance measures (e.g., reducing fall fatalities by 20%). Emphasis is now placed on focusing research so that it makes measurable contributions to society.

The Construction Program was the second NIOSH program after the Mining Program to develop strategic goals. The draft goals were discussed with construction stakeholders such as the Construction Center researchers, ACCSH, the BCTD Safety and Health Committee, the National Safety Council Construction Committee, and the American Industrial Hygiene Association Construction Committee. The draft goals were also announced in the NIOSH e-news and posted on the NIOSH website for comments at http://www.cdc.gov/niosh/topics/construction/draftgoal-inst.html. After review by the NIOSH Leadership Team, the Construction Program began using these draft goals for internal project planning in 2005.

NIOSH announced a new initiative called R2P for "Research to Practice" in 2005. R2P focuses efforts on the transfer of research findings and technologies the workplace. This was an important and relevant development for the Construction Program given ongoing interest in translation and diffusion issues.

During this period, NIOSH leadership reviewed the status of NORA, then entering the 9^{th} year of a decade-long effort. NORA was viewed as successful, and a decision was made to continue a modified NORA for a second decade. NORA was re-oriented around industry sectors – and construction was selected as one of 8 sectors. A sector approach was viewed as a good fit with how labor and industry stakeholders were organized, and these groups were viewed as important for increasing R2P activities over the decade. The NORA2 concept involves each sector developing a "National Agenda" to address top problems for that sector over the next 10 years.

A NORA "town hall" meeting for the construction sector was held in Chicago in 2005 and a NORA webpage for submitting electronic comments was also established. The CSC transitioned to serving as the NIOSH representatives to the NORA Construction Sector Council, which held its first meeting with stakeholder candidates in 2006. Construction was the first NORA sector to hold a Sector Council meeting. The Construction Program members of the Council provided the draft Construction Program strategic goals as input to the process of identifying top problems. The meeting identified some topics for additional discussion, and identified other construction groups to include on the Council for the next meeting. The Council met again in 2006 and identified a list of "top problems." Additional information about the NORA Construction Sector Council, and the top problems identified is provided in Chapter 4.

In December of 2006 NIOSH announced an internal competition for "Public Health Practice" projects to provide the new NORA sectors with opportunities for development of R2P and similar projects. The Construction Program is pursuing several projects, including one to pilot dissemination of construction safety information at big box hardware stores to reach small contractors and another to track use of NORA-generated research by stakeholders over the next decade.

Strategic Planning during this period 2005-2007

The Construction Program completed work on a set of draft strategic goals in 2005 to guide future research. Since the NORA2 effort also involves the development of construction sector goals, we believed that completing NIOSH Program goals prior to the NORA process might confuse some stakeholders about our intentions to participate in NORA and would deprive us of potentially valuable input via the NORA process. We revised our plan and contributed our draft Construction Program goals as input to the NORA2 process for construction. We also announced our interest in adjusting our draft goals (especially intermediate goal concepts) and timeframes based on Sector Council discussions and input. The Sector Council is discussed in more detail in Chapter 4.

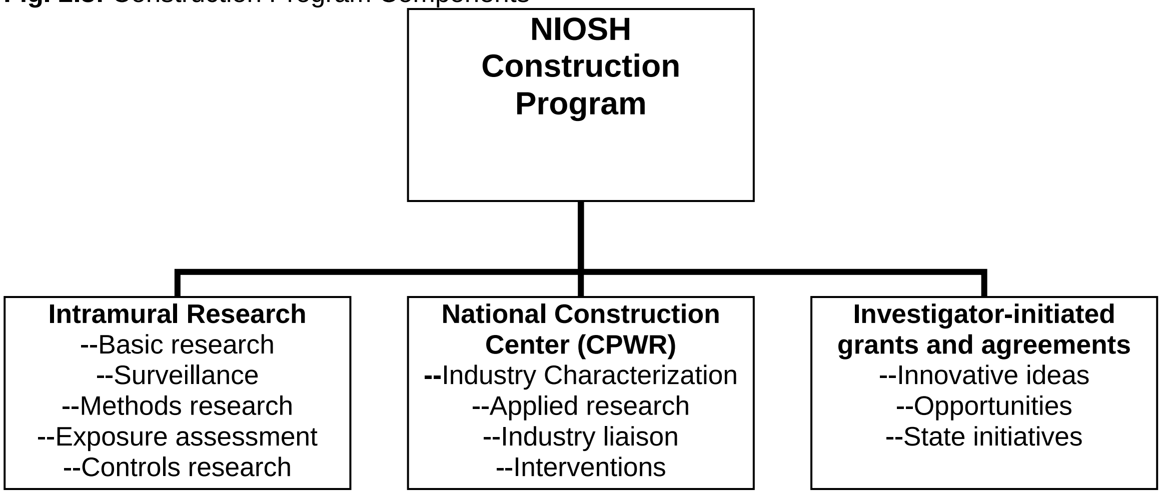
Goals used for the Evidence Package

The National Academies' reviews of NIOSH research programs generally focus on the period from 1996-2006. As mentioned, the Construction Program strategic planning has evolved over this period – beginning with input from the NIOSH-wide 21 NORA1 priority topics; transitioning to Construction Program "high priority topics"; and continuing on to the development of draft NIOSH Construction Program goals. Accordingly, the four goals and 18 subgoals listed in this report represent a composite of the goals in place during this period, with emphasis on integrating the high priority topics and the NIOSH draft strategic goal topics. While there is some overlap, the goals used for the evidence package do not explicitly include the NORA Construction Sector Council topics, as they are still under development.

2.3 Program Structure, Planning, and Resources

Figure 2.3 provides a conceptual overview of the NIOSH Construction Program and its components.

Fig. 2.3: Construction Program Components



The three program components are: (1) an intramural component based in NIOSH divisions and laboratories, (2) a National Construction Center operated under competitively awarded five year cooperative agreement cycles; and (3) investigator initiated extramural grants and support for state health department investigators working on construction issues. The structure reflects recognition of the value that extramural activities contribute to the program. The boxes in Figure 2.3 show the research strengths that each component brings to the program. NIOSH brings basic research strengths which are leveraged via interactions with Construction Center industry links and applied research strengths. Investigator-initiated grants tap the ideas and opportunities identified by individual researchers. State health department researchers also initiate various construction initiatives – typically related to surveillance and state level interventions.

For the sake of readability, and reflecting that the components are all part of a single program, the evidence package will not provide attribution at the component level when describing activities. We will refer to “Construction Program researchers” as an umbrella term to describe intramural researchers, Center and Center Consortium researchers, and state and individual investigators. We will refer to “Construction Center researchers” or provide the name of an academic institution on occasion to help portray for readers the roles and contributions of the different organizations that comprise the program. Please keep this in mind as you read Chapter 3.

Intramural program structure
The intramural Construction Program uses a Coordinator and a Construction Steering Committee (CSC) with membership from each NIOSH division and laboratory. They work with the NIOSH management structure to advise on the conduct of Program-related activities. The CSC meets monthly via videoconference or conference call and typically holds two yearly face to face meetings. The CSC briefs the NIOSH leadership on relevant issues.

Intramural project planning and funding methods
Currently there are two separate processes for intramural research project planning and resource allocation. One process is conducted at the division/laboratory level based on an annual allocation to each operating unit. That allocation is determined by the NIOSH Office of the Director. Research planning for this process is primarily a bottom-up approach. Investigators propose research projects that align with the program priorities of the operating unit, with some consideration of other safety and health priorities (such as those of the Construction Program). The Construction Program provides copies of current strategic priority and goal topics as an appendix that goes out to all researchers as part of the annual project planning guidance. The division construction steering committee representative provides added influence to the process. Each operating unit receives a specific annual allocation for construction research.

Research concepts are developed by investigators and are rated and ranked by the operating unit's management based on importance of the problem, soundness of approach, and expected impact. The highest-ranked concepts are approved for implementation based on available funding. The Construction Steering Committee reviews all new construction-related projects. The Committee provides feedback to the division along with any guidance for the investigator. When a project ends (due to completion or discontinuation),its funding returns to a pool within the operating unit.

At the Institute level, there is an annual opportunity for NIOSH researchers to compete for project funding from a set-aside of intramural NORA funds. The process is similar to the competition for extramural R01 funding: submission of responsive letters of intent (LOIs) followed by full proposals which are externally peer-reviewed and scored. Funding decisions based largely on peer-review scores and available funding are made by the Director of NIOSH. While the Director may call for proposals in specific emphasis areas, proposals compete across program areas. Upon project completion, funds return to the NORA pool for renewed intramural competition and distribution across programs. NIOSH is in the process of transitioning the entire NIOSH research program planning and funding process to a sector-based, strategic goal-oriented one that will operate across operating units.

Extramural funding methods
Extramural Construction Program research is funded through three methods. First, the program uses Construction Center cooperative agreements. The cooperative agreement RFA announcement is used to communicate strategic direction and research needs for five-year periods. The second method is partnerships with NIOSH divisions and other programs to support targeted RFAs and cooperative agreements. Examples include support for the state FACE cooperative agreement (targeting construction fatalities), or the ABLES cooperative agreement to support state efforts in blood lead surveillance and intervention. The third method is the NIOSH general program announcement.

Construction Center
NIOSH views the Construction Center as a critical component of the Construction Program. It provides important linkages to the construction community and it focuses and coordinates research that is often more applied than NIOSH intramural research. Structured as a cooperative agreement, it is intended to promote dialog and collaboration among researchers. The Construction Coordinator meets with senior Center personnel on a regular basis. Intramural and Center researchers working on related topics communicate and sometimes collaborate on projects. The Center provides field contacts for intramural researchers interested in pursuing field studies. The Center uses twice a year face to face "Consortium meetings" as a vehicle for researcher to researcher interaction and for interaction with NIOSH Construction Steering Committee representatives. The Center to Protect Workers Rights (CPWR) and their university consortium has successfully competed for the Construction Center cooperative agreements.

Construction Center project planning
The Center engages in a robust planning activity that includes: 1) A review of national surveillance data to identify research problems; 2) use of stakeholder meetings (recently, 21 were held with approximately 600 participants in all regions of the country); 3) an analysis of all NIOSH and CPWR intramural and extramural activities to identify areas of cooperation and "gaps" that have not been addressed by research; and 4) a national search to find the best possible consortium collaborators. During the most recent cooperative agreement application process, this resulted in over 100 responses in the form of concept descriptions. From these concepts, CPWR selected about two dozen for submission as full proposals, and from these it selected 16 projects for inclusion in the final application.

The CPWR Center Director uses a technical advisory board to provide advice and oversight for Center activities. Current board members are listed in Table 2.3

Table 2.3 CPWR Technical Advisory Board (2007)	
Name	**Affiliation**
Dr. Anders Englund, Co-chair	Director, Division of Medical Affairs, Swedish Work Environment Authority (Ret)
Dr. Ralph Frankowski, Co-chair	Professor, Department of Biometry, University of Texas Health Sciences Center, Houston
Robin Baker	Director, Labor Occupational Health Program, University of California, Berkeley
Dr. Christine Branche	Injury Prevention Specialist
Dr. Eula Bingham	Professor, Department of Environmental Health, University of Cincinnati Medical Center
Dr. Letitia Davis	Director, Occupational Health Surveillance Program, Massachusetts Department of Public Health
Denny Dobbin, MsC, CIH	Environmental Adviser
Dr. James Melius	Administrator, New York State Laborers Tri-Funds
Dr. Linda M. Goldenhar	Director of Evaluation, Medical Student Education, University of Cincinnati College of Medicine

2.4 Construction Program Operational Logic Model

The Construction Program logic model parallels the NIOSH operational logic model. It depicts the flow of research and transfer activities for the Construction Program. This process proceeds from left to right on the model from inputs through research activities and outputs to customer activities and intermediate outcomes. For the Construction Program, end outcomes are the actual reduction in injuries, fatalities, exposures, illnesses and disorders in construction workers. The blocks in the center of the logic model provide details about the general categories (e.g. inputs, outputs, etc.) that are depicted in the boxes across the top. We recognize that the transfer activities shown on the right half of the logic model often involve steps and actions that are beyond our control, and for which we are dependent on customers and other stakeholders. We also recognize that various external factors, represented on the logic model as arrows along the bottom, affect all aspects of the program, from inputs to outcomes. The organization of this evidence package is based on the logic model, and the flow of our efforts as shown in the model in Figure 2.4.

Inputs

Planning Inputs – These include Congressional directives, stakeholder input from conferences and symposia, program evaluations, and program goals. They also include injury and illness surveillance data, partnership information, and evolving research findings.

General Appendix 1 describes the Program’s history, including these inputs. They range from the original Congressional language establishing the program, to the national conferences (1990, 1993, and 1995) that provided early stakeholder input, the 1996 program review, and the recent evolution of goals to provide strategic program direction.

Other general drivers of the Construction Program include:

- The public health model as research framework, to ensure a multidisciplinary approach and commitment to follow-through from data-driven conceptualization to workplace implementation.
- Research-to-Practice (r2p) as a framework for insuring that research results in impact for our end customers – workers and contractors.

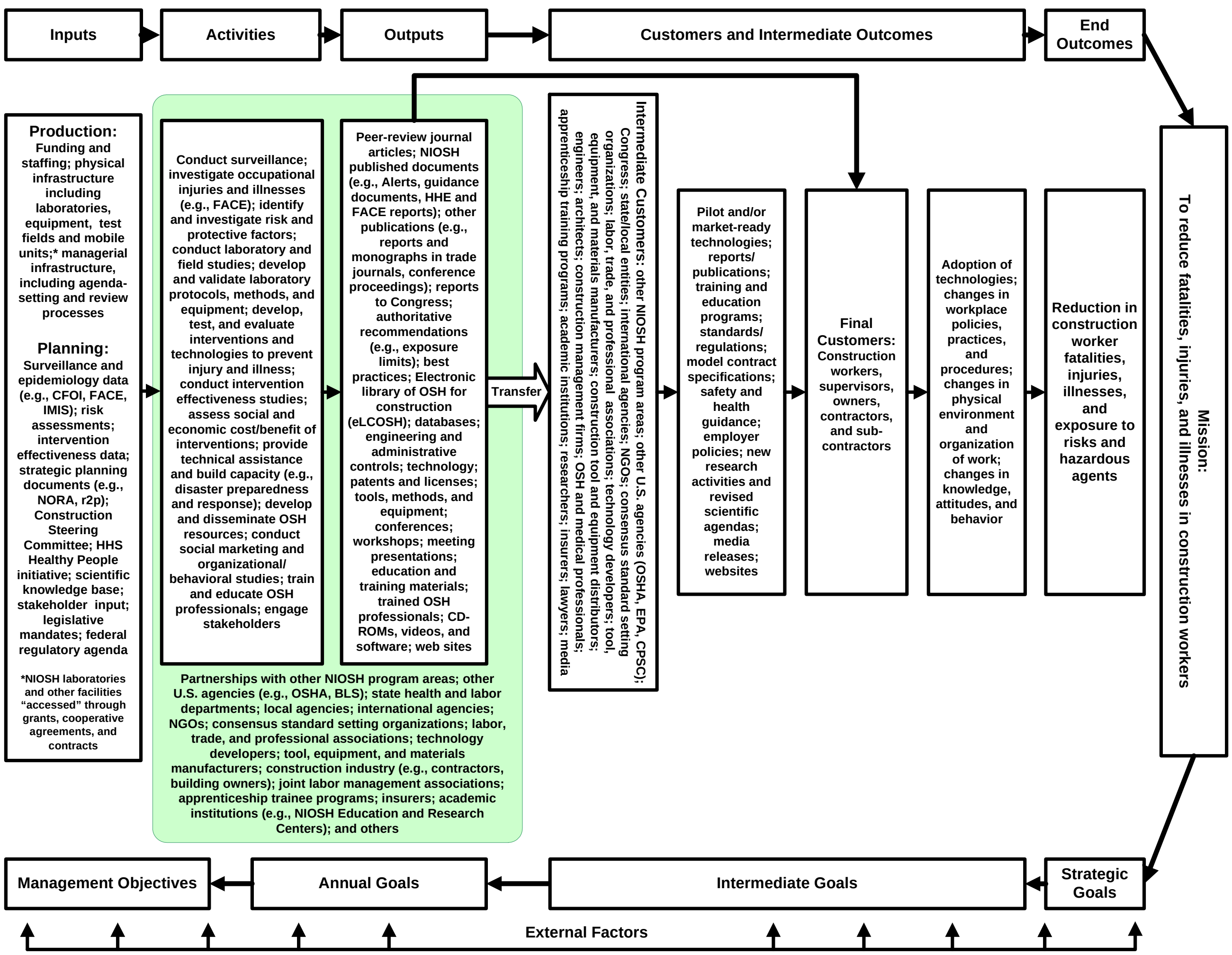


Figure 2.4 – NIOSH Construction Program Logic Model

<u>Production Inputs –</u> These include budget allocations, staff, facilities, management structure, extramural entities and partners.

<u>Funding –</u> Funding for the Construction Program over the period from (1997 to 2007) has averaged about $17.8 million and had ranged from a low of $13.8 million to a high of $20.3 million. See table 2.3 for the Construction Program budget history.

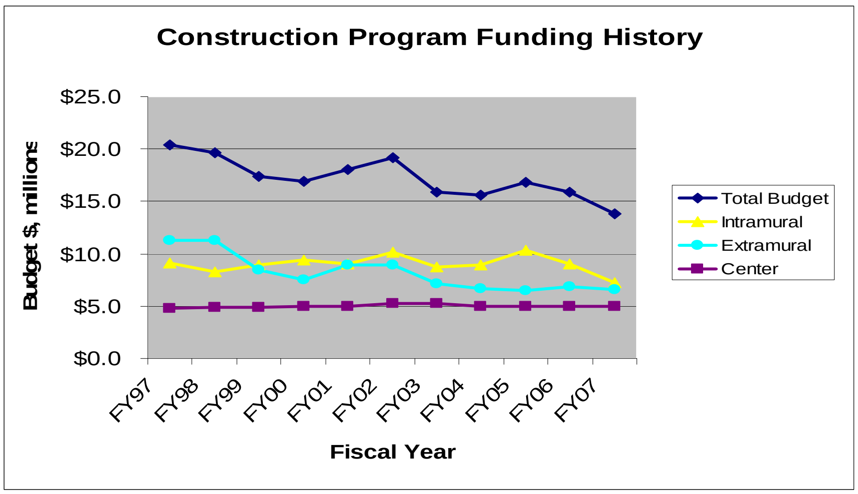


Table 2.4 NIOSH Construction Program Budget History – 1997 – 2007 NOTE: The Cyan line shown for the Extramural budget includes the amount shown by the Purple line for the Construction Center.

Given the reality of inflation, the funding level has declined in real purchasing power. See Table 2.5 for the budget from FY 00 to FY 07 adjusted for inflation.

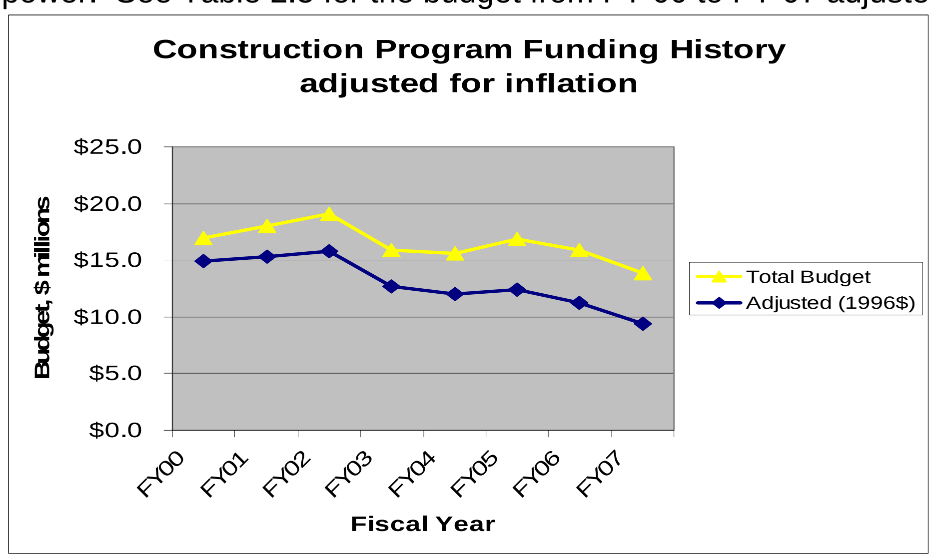


Table 2.5 NIOSH Construction Budget Funding History for the years FY 00 to FY 07 showing the Total Budget and the Budget adjusted using the Biomedical Research and Development Price Index

The Budget picture can also be viewed from the perspective of spending on the four Construction Program Goals described in the Evidence Package. Table 2.6 presents the Construction budget for each of the four research goals along with expenditures for support.

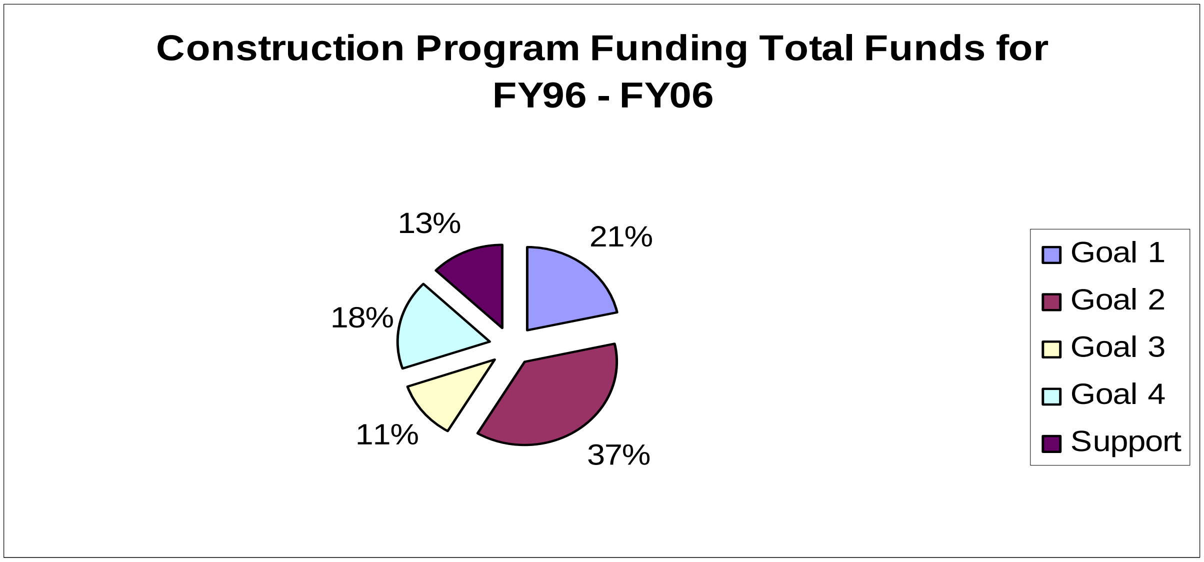


Table 2.6 Construction Budget Funding – breakdown by the four Construction Program Goals for the years FY 96 to FY 06

Table 2.7 shows the four goal areas showing the relationship between intramural and extramural spending.

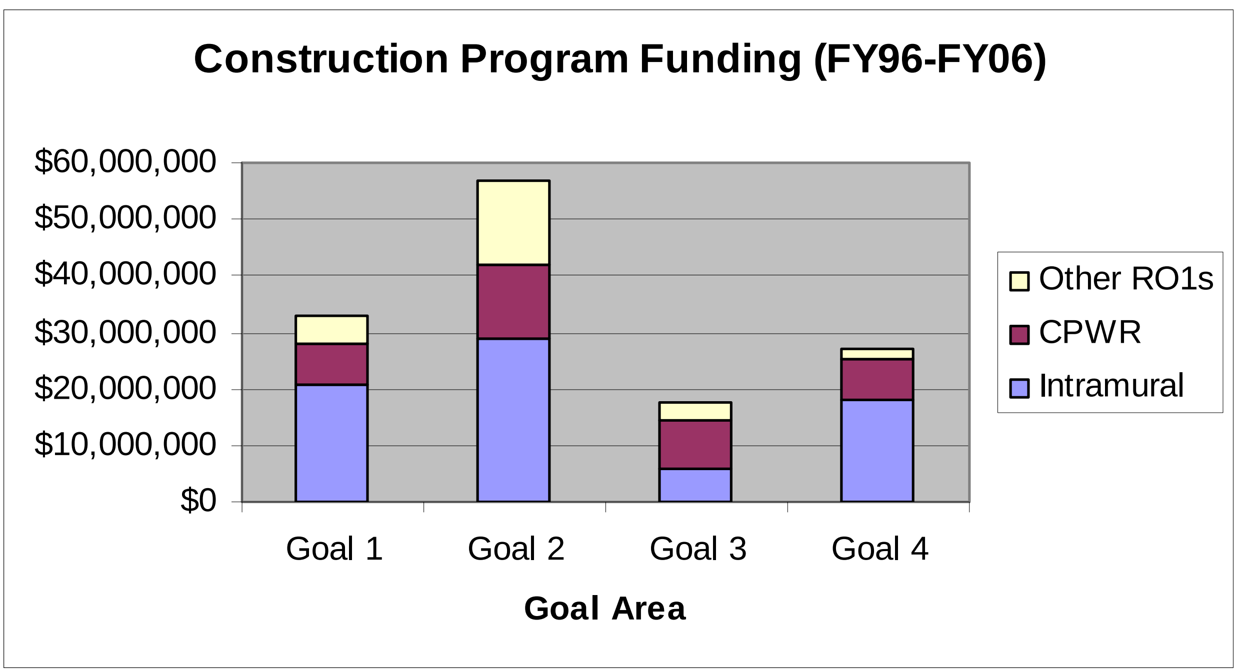


Table 2.7 Construction Program Funding by the four goals for the years FY 96 – FY 06 showing the relationships between program component contributions.

Personnel – Intramural As a matrix program, the total FTE commitment represents the contributions of researchers in each division and lab engaged in research coded as construction plus the Institute-wide steering committee and coordinator. The research FTE commitment was 56 FTEs in 2007 representing individuals in a variety of disciplines including epidemiology, safety engineering, safety management, statistics, general engineering, communications, industrial hygiene and health science.

Construction Steering Committee representatives allocate 10% of their FTE to participation on the Committee. The Construction Coordinator allocation has ranged from 25% in 2000 to 100% at present. Beginning in 2006 with transition to NORA2, a senior Lead Team representative was designated as Construction Program Manager and the steering committee representatives transitioned to also representing NIOSH on the NORA Construction Sector Council. Current intramural component researcher CVs are included in Appendix 2.2

Personnel - Center CPWR has 16 internal researchers and support personnel representing 30 FTEs working on Construction Program research. These individuals represent disciplines including epidemiology, safety engineering, safety management, statistics, general engineering, industrial hygiene, science, medicine, toxicology, and economics. CPWR also has developed a consortium of 15 academic and other institutions working on various Construction Center projects. The Center cooperative agreement also includes a "Small Studies Program" to award funding of up to $30,000 to support projects based on merit that could have a practical impact on the construction industry. CPWR developed this approach to use a simplified application process to encourage researchers to investigate opportunities that arise with short notice, and also to provide a mechanism to bring new investigators into the field of construction safety and health. It has proven to be an innovative and active program. An evaluation of this program was performed and reviewed by the CPWR Technical Advisory Board in May, 2003. Since inception, it has received over 90 letters of intent, and of 83 applications submitted, 42 have resulted in awards. The funded studies were evenly divided between surveillance, intervention and policy /economics research. Many of these awards were to young investigators [Ringen 2003].

The current Center consortium includes 26 individual PI's affiliated with the following institutions:

CPWR
Harvard University
Hunter College
Duke University
Rutgers University
University of California, San Francisco
University of Massachusetts, Lowell
University of Washington

University of Washington, St. Louis
Florida International University
Hazard Information Foundation, Inc.
Oregon University
Colorado, State
University of Illinois
West Virginia University
University of Iowa
University of Tennessee
Pacific Research Institute
University of North Carolina

Current Construction Center CVs are included in General Appendix 2.

Personnel - Extramural – other investigators The Construction Program currently interacts with several other extramural partners. These include a “Center for Innovation in Construction Safety and Health” at Virginia Tech and several R01 researchers. We also interact with individuals associated with state health departments involved with fatality investigation and intervention programs, and blood lead reporting and intervention programs. Other construction researcher CVs are included in General Appendix 2.

Activities

Activities are efforts that use the inputs to accomplish the objectives of the program. Activities are performed by the Construction Program intra- and extramural staff and their partners. Efforts include surveillance, research, and intervention development and testing. The activities stage involves a sequence that follows the public health model from identifying a problem through surveillance findings to identifying risk factors, developing prevention strategies, evaluating promising interventions, and facilitating the transfer and adoption of prevention strategies in the workplace. Complicating factors include the need to examine variations in practice, address gaps, and apply research to other occupations or tasks.

We use the term “partners” to refer to stakeholder groups that collaborate with us on program activities. Partnerships are integral to the Construction Program. Research with our partners may include in-kind contributions that help to leverage NIOSH research dollars. Partners sometimes add expertise or specialized experience to the research team. In recent years, there has been an increase in multiple partner projects that bring together various key players involved with a given construction issue. Several examples of partnerships are described in Table 2.4

Table 2.4 Examples of Construction Program Partnerships

-Occupational Safety and Health Administration (OSHA)
We coordinate with OSHA through meetings and participation in OSHA's Advisory Committee for Construction Safety and Health (ACCSH)..NIOSH has worked with OSHA's Directorate of Construction and an ACCSH trenching workgroup to develop outreach materials to target trenching and excavation fatalities. OSHA developed quick cards and posters; the Construction Program developed a Trench Safety Awareness Training CD-ROM. OSHA sent these materials with a letter from the Assistant Secretary to more than 5000 contractors to date.

-Midwest Tool and Cutlery Company
The Construction Program is partnering with this Michigan manufacturer of non-powered construction hand tools and Colorado State University to evaluate two ergonomically improved manual cutting hand tools used by workers in the sheet metal and other construction trades.

-Larson-Davis Company
We are partnering with this noise instrumentation company to test and evaluate prototype systems for accurately capturing and analyzing impulsive noise in real time. Impulse noise is recognized as an important concern for construction. NIOSH has entered into a Cooperative Research and Development Agreement (CRADA) to develop these systems.

-Laborer's Health and Safety Fund of North America (LHSFNA)
We are partnering with the LHSFNA to evaluate bilingual construction training materials to provide information about ways instructors, supervisors, and employers can more effectively meet the learning needs of Spanish-speaking workers.

-United Brotherhood of Carpenters and Joiners of North America (UBC)
We are working with the carpenter apprentice training centers in the Ohio and Indiana area to investigate the risk for occupational hearing loss among carpenters and millwrights and to develop interventions specifically designed to prevent occupational hearing loss among these workers. The long-term goal has been to develop hearing loss prevention tools that can be applied to other construction workers, as well as to workers in other industries. The partnership developed a hearing loss prevention program that is a model for the construction industry. It also performed a pilot study that showed that a training program positively influenced attitudes and beliefs about preventing occupational hearing loss and increased worker skills at fitting and using hearing protection.

-National Association of Tower Erectors (NATE)
Since 1997, NIOSH, NATE, and OSHA, have worked together closely as partners to improve the safety and health of tower erectors. NIOSH findings and injury prevention recommendations from the NIOSH Fatality Assessment and Control Evaluation (FACE) project have been used by OSHA and NATE to improve the safety and health of tower workers. We originally reviewed existing data systems and found more than 200 fatalities associated with tower erection during an 11-year period. We provided technical assistance and input for regulatory guidance and assisted with the development of train-the-trainer courses. Our data analysis, information from fatality investigations, and recommendations are used by OSHA and NATE as training materials, and NATE has distributed more than 7,500 copies of the NIOSH Alert to conference attendees

-**Hunter College, Labor/Management Craft Committee of the International Union of Bricklayers and Allied Craftworkers (BAC), and the International Masonry Institute**
Center researchers are evaluating an intervention that will develop and disseminate a contractor certification program recognized by owners, workers and their unions, regulators, and insurance carriers. The intent is to lead to the systematic adoption of silica control programs by masonry restoration contractors in the New York area.

The Roadway Work Zone Safety and Health Coalition-American Road and Transportation Builders Association (ARTBA), International Union of Operating Engineers (IUOE), Laborers' International Union of North America (LIUNA), National Asphalt Pavement Association (NAPA), OSHA
The Construction Program is working closely with this partnership and alliance on a number of issues, with a particular focus on safe work zone research. We reviewed highway safety literature, analyzed fatality and injury data, and convened a meeting of work zone safety stakeholders. The meeting led to the creation of the NIOSH publication: *Building Safer Highway Work Zones*. It presents complementary prevention

measures to protect workers from hazards posed by construction vehicles and equipment as well as by traffic vehicles. The partners helped to identify several promising interventions for further reducing the incidence of highway construction workers getting struck by construction vehicles. NIOSH lab and field research is evaluating the effectiveness of *Internal Traffic Control Plans*, proximity warning devices, and blind area diagrams for construction vehicles. Upon completion, the partnership will work to transfer successful solutions into construction practice.

International Union of Operating Engineers, CPWR, Zachry Construction Corp., Allied Safety Systems, Inc., Hirschmann/ PAT America, Inc., and OSHA
The Construction Program is partnering with a diverse group of labor, industry, users, manufacturers, and government partners to develop meaningful, real world evaluation criteria for power line proximity warning systems. This group has devised criteria to allow testing of proximity warning systems at full scale voltages up to 25kV at the NIOSH Pittsburgh Research Lab's newly constructed power line test site. Performance data from these tests will be used to further develop national standards for use by OSHA-recognized testing laboratories to performance test such systems.

Arizona Roofing Contractor Association, CPWR, United Union of Roofers, Waterproofers and Allied Workers, OSHA, Petersen Dean
We are working with these groups to evaluate silica and noise exposure controls for tile roof installers. Cement tile roofs are more common in the South, and NIOSH has recently found that cutting tiles can generate overexposures to respirable silica. NIOSH is working with these groups to identify and evaluate engineering controls for cutting concrete roofing tiles such as wet cutting, use of local exhaust ventilation, and use of cutting stations.

New Jersey Silica Partnership-Utility and Transportation Contractors Association of New Jersey Associated General Contractors, Laborers' International Union Locals 172 & 472, New Jersey Laborers' Health and Safety Fund, New Jersey Department of Transportation, New Jersey Department of Health and Senior Services, New Jersey State Safety Council, New Jersey Turnpike Authority, New Jersey Department of Labor On-site Consultation Service, OSHA
The Construction Program worked with this large group of partners to evaluate and reduce or eliminate the amount of respirable crystalline silica dust to which workers are exposed during heavy highway construction in New Jersey. The partners first defined the problem by surveying actual highway construction projects in New Jersey to identify where excessive exposure to crystalline silica was most prevalent. This identified many routine tasks such as jackhammering and drilling, which led to development and testing of control prototypes. All of the resulting devices reduced operator dust exposures by at least 50%, and one of the controls-a water spray dust suppressor-reduced respirable dust levels by as much as 90%. The partnership is now evaluating the water spray control on actual job sites. The partners also developed and provided silica-related outreach in the form of training, guidance, and best practice bid specifications, and identified cost effective ways to reduce costs and time delays associated with respirator fit testing.

Outputs

Outputs result from activities. They include scientific reports such as peer-reviewed journal articles, technical reports, meeting presentations, book chapters, and review articles. Scientific publications are essential to advancing the body of knowledge on construction safety and health and for communicating results to scientific and regulatory audiences. Another type of output is recommendations, from those included in scientific publications to more general ones found in NIOSH or Center Alerts. Since the program develops and evaluates tools, methods and technologies, another class of outputs is documentation of inventions, patents, and new methods. Examples include task-based exposure assessment methods, new worker training techniques, and efficacy demonstrations for control technology. Conference presentations are an additional type of output, and research and construction stakeholder meetings are used for transfer of results to others.

The Construction Program also emphasizes the development of outputs that translate scientific information into easily understood materials to target construction sector audiences. For example, articles for union and trade association publications, pocket card-sized materials, and CD-ROMS and DVDs suitable for construction apprentice or journeyman upgrade training.

During the years 1996 through 2006, we estimate that the Construction Program has produced over 600 peer-reviewed journal articles on construction safety and health topics and provided over 500 presentations. During this time, about a half million copies of numbered NIOSH publications have been distributed. This figure includes copies that have been proactively distributed by direct mail through targeted dissemination as well as copies that have been distributed at various conferences and exhibits. During this time, the Construction Center has disseminated over 26,000 hard copies of reports (95% have been requested by customers) and over 1 million copies of pocket cards about construction issues developed with support from the program. We have also used website topic pages to ensure widespread dissemination of our research. The “Electronic Library of Construction Safety and Health “(eLCOSH) was launched in 2000 to disseminate construction materials. The site, described further in the Goal 4 section, currently gets 2 million hits a year.

More information on Construction Program outputs, the distribution of construction-related NIOSH publications, and the citations of Construction Program peer-reviewed articles in other research publications is contained in the Appendix accompanying each of the goals found in Chapter 3.

Intermediate and End Outcomes

Intermediate outcomes are responses by Construction Program stakeholders and customers to its products. We use the term intermediate customers to describe groups such as:

-Other extramural researchers
-Other U.S. agencies such as OSHA, EPA, or CPSC
-Congress
-State and local governments
-Non-governmental organizations (NGO’s) and consensus standard setting groups
-Labor unions and trade associations
-Professional associations
-Technology developers and tool, equipment, and materials manufacturers and distributors
-Engineers, safety and health professionals, architects, medical professionals
-Construction Management firms
-Apprenticeship training coordinators
-Academic institutions

-Workers compensation carriers
-Attorneys
-Media

Use of our program research by these groups can lead to intermediate outcomes such as:

-Increased research and use by other researchers and research organizations
-Use by construction employers such as adopting safer work procedures
-Direct compliance or inspection activities by agencies with specific jurisdictional authority
-Incorporation of information in new regulations, guidance, or consensus standards
-Increased awareness of construction risks and prevention options
-Acquisition and use of new equipment, methods, and products featuring safety-enhanced design
-Incorporation of information and concepts in construction training
-Further dissemination and use of information by construction trade associations and unions.

Chapter 3 of this evidence package includes descriptions of how construction stakeholders have used or are using Construction program outputs. These range from using research to support construction regulations and consensus standards to use of program developed methods by other federal agencies. They include examples where stakeholders link to Construction Program products or disseminate them to their members and affiliates. Several examples are provided below:

-Program researchers, working through a partnership involving labor, management, equipment supplier, and government client groups, helped develop and independently evaluate asphalt paving vehicle controls for reducing operator exposures. The group agreed to a nationwide plan to install the resulting controls on all new highway class pavers. This type of paver accounts for about 90% of the hot mix asphalt placed annually.

-Program supported academic researchers in the state of Washington developed a website and specific worker and supervisor training materials for 11 different trades to disseminate noise and hearing protection findings from their research. The Washington Department of Labor and Industries distributes the materials to businesses within the state and a company that makes hearing protection used the construction-specific hearing protection recommendations from the study to develop a new hearing protector with a moderate noise reduction rating appropriate for certain construction uses.

-“Design for Safety” materials developed by a Center researcher were customized and used by Washington Group International (WGI), a large international construction firm to deliver full-day training programs using corporate resources to more than 500 (as of spring 2007) of its engineers. WGI plans to continue this program until all 1,800 of its engineers globally have received basic design for safety training

-The success of the *Smart Mark* program initially developed through Center efforts has been demonstrated through its adoption by construction project owners (Tennessee Valley Authority employing over 15,000 construction workers on a given day) and states (Connecticut, Massachusetts) and the number of construction workers (approximately 50,000/per year with over 500,000 workers trained since program inception) who are trained and certified according to the Smart Mark program. Intermediate customers associated with *Smart Mark* are construction owners and users, employers, unions, and joint labor/management training centers, among whom are 4,000-5,000 training instructors certified to teach the *Smart Mark* training program.

End outcomes are reduced injuries, deaths, illnesses, or hazardous exposures that result from either the outputs or intermediate outcomes of the Construction Program. They are generally beyond the direct control of the Program, and are difficult to causally connect with Program outputs and intermediate outcomes. Nevertheless, the Construction Program uses them in our logic model to focus the Program on research that benefits workers.

External Factors

A variety of factors add to the challenges of improving safety and health in construction --several are described below:

Nature of construction – Each job has its own learning curve involving unique site conditions and a unique work crew. Short duration jobs, temporary conditions, and tight schedules discourage installation of equipment to control or prevent exposures. Work is done outside in various weather and seasonal conditions which can contribute to hazards. The absence of steady employment for construction workers can contribute to a climate where workers are hesitant to report minor injuries or complain about safety and health conditions. The temporary nature of construction also presents an important obstacle to recognizing links between occupational health exposures and outcomes – for both workers and employers.

Small employer dominance – About 80% of construction employers have fewer than 10 employees. It is more difficult for small employers to support part or full-time safety and health professionals on staff. Additionally, small employers may not belong to trade associations and thus may not hear about best practices or new hazards via these channels.

Competitiveness – Construction is extremely competitive, and many construction jobs, even for large owner clients or governments, are awarded to the lowest bidder. While this ensures competitiveness, it can adversely impact safety and health when contractors undercut costs associated with safety and health expenditures. Competitive pressures may be contributing to structural changes in construction such as the increasing informal construction sector where each worker is an independent contractor responsible for his or her own safety.

Fragmentation – Having multiple employers on a typical site can blur safety and health responsibilities. For example, elevated noise levels created by one contractor may impact nearby employees working for another contractor. A recent OSHA Review Commission decision (Summit Contractors Inc) overturning a decades old multi-employer worksite doctrine[8], will contribute to uncertainty on lead roles in multi-employer settings. Fragmentation also affects professional disciplines – which safety and health duties belong to architects, which to engineers, which to safety and health professionals, which to competent persons and or the superintendent on the job? Pinpointing responsibility for safety and health on a project can be difficult. At each layer, from owner/user to designer/ engineer/ architect; from owner to prime contractor to subcontractor; from employer to worker; and contractor to supplier, the duty to protect safety and health is defined in shades of grey.

For chronic health risks, defining responsibility extends beyond the project site. With most workers being employed only for the duration of tasks, and moving from job to job and from employer to employer, chronic health conditions (e.g., noise induced hearing loss which affects most construction workers) typically do not result from one job, but from a career involving many employers over many years.

Proprietary perspectives – The diffusion of many safety and health resources is limited because they are available only to members of a trade association, owners group, union, or labor/management fund. Membership organizations have a vital role in the industry but this inadvertently limits sources of safety and health information available for smaller employers or the two and a half million self-employed construction contractors.

Separate regulatory tracking – The Occupational Safety and Health Administration (OSHA) regulates construction separately from "General Industry". While this ultimately produces regulations that more closely fit construction conditions and practices, in the near term it results in multi-year delays in developing construction regulations. General industry regulations are typically developed first with construction regulations developed at a later time on a separate rulemaking track. General industry regulations cannot legally be

[8] In a 1976 case, the OSH Review Commission rendered a decision that "we will hold the general contractor responsible for violations it could reasonably have expected to prevent or abate by reason of its supervisory capacity." The Summit case can be found at http://www.oshrc.gov/decisions/html_2007/03-1622.htm

enforced for construction, and a number of important hazards in construction such as silica and hearing conservation are either obsolete or lacking. While regulations may be a less important driver for large construction firms guided by best practices, regulations play an important role in raising awareness and providing a risk management framework for the many small and medium sized firms in the construction industry. OSHA recently used a comprehensive approach to develop regulations for all three industry groupings (general industry, construction, and maritime) at the same time for hexavalent chromium and OSHA is planning to issue a proposed silica rule for construction in the near future.

Limitations in sector research support – The construction industry as a sector appears to provide a lower level of support for research of any kind. For example, available estimates from the mid -1990's suggest that the construction industry invests less than 0.5% of the value of its sales in research and development, whereas the national average is closer to 3% [NIBS 1996, NSB, 1998].

Obstacles to field research - Field research is the "gold standard" for both occupational researchers and construction stakeholders. Yet the episodic and improvised nature of construction work makes it challenging —and frequently frustrating—for researchers to capture and measure risks to safety and health. As a result some occupational safety and health researchers shy away from the industry or have difficulty getting started. If the controlled environment of the laboratory is the ideal setting for scientific research, then the construction setting represents the opposite extreme.

Several positive external factors include:

Semi-autonomous workforce – Construction workers bring a set of trade and problem solving skills to each job and are expected to innovate when needed with less supervision than workers in many other types of sectors. Making change in the construction industry is possible because it is by nature very opportunistic, flexible and oriented towards solving problems. Researchers who are able to interact with construction workers in the field commonly receive valuable input that improves intervention prototypes. Combining safety and health and construction know-how has lead to breakthroughs in areas such as ergonomic innovations.

Existing training infrastructures **-** A variety of existing training mechanisms exist to provide trade skills and know-how to employees. These provide high quality training and are receptive to providing safety and health training – especially training required for a specific credential or to comply with a specific regulation.

Active consensus standard setting – The construction community supports an active consensus standard infrastructure with broad participation and support by a cross-section of construction stakeholders. Groups such as the American

National Standard A10 Committee have developed and continue to develop a number of consensus standards addressing construction safety and health issues.

State and locality interest in safety and health – States are increasingly recognizing the value of state level safety and health interventions. For example, Massachusetts and Rhode Island require minimum 10 hour employee safety training prior to state-sponsored construction work and New Jersey and California have explored contract and regulatory mechanisms to address silica exposures. The Construction Program is working to provide technical resources and information as appropriate.

2.5 Impact

Given the nature of a research program, it is a major challenge to directly impact prevention or to demonstrate a cause-effect relationship between our work and outcome metrics. We achieve our impact by working indirectly through and with our customers and partners. However, we believe that the Construction Program has made important contributions to construction industry performance since program inception in 1990.

Prior to 1990 there were few safety and health researchers specializing in construction safety and health. The Construction Program built research capacity to address construction knowledge gaps. Research outputs from the program provided an evidence-based foundation to supplement professional opinion for guidance, regulation and stakeholders practices. National Construction Conferences held in 1990, 1993, and 1995 brought together stakeholders across the industry for the first time. These conferences were designed to raise awareness, challenge the industry, and disseminate best practices. They integrated research with implementation and follow-up. For example, the 1995 conference reported back that the 1993 conference recommendation to pursue new approaches such as negotiated rulemaking had led to expedited development of steel erection regulations to address an important source of falls. Program emphasis has followed a strategic and purposeful evolution from these early days. An initial focus on surveillance and problem identification evolved to development and evaluation of interventions tailored to construction, and then to an increasing emphasis on diffusion and implementation of effective interventions.

The Program incorporated construction national injury and fatality outcome goals from program inception via development of Healthy People 2000 benchmarks. This aligned efforts with national prevention and health promotion goals at the Department of Health and Human Services level, and helped to communicate their importance to researchers and stakeholders. These initial goals called for a 30% reduction in nonfatal and fatal injury rates over the decade. These goals were met and exceeded during the first decade of the Construction Program:

- Non-fatal injuries: the injury rate by 1999 was 8.7 injuries per 100 fulltime workers, better than the 30% reduction target of 10 injuries per 100 full-time workers.

- Fatal injuries: the fatal injury rate by 1999 was 14.0 per 100,000 workers, better than the 30% reduction target of 17.0 deaths per 100,000 over the evaluation period.

The corresponding *Healthy People 2010* targets developed for the second decade of the program again call for 30% reductions using 1998 baselines of 8.7 nonfatal injuries per 100 fulltime workers and 14.5 fatal injuries per 100,000 workers. With five years still to go (the most recent available data are from 2005), the available metrics show that the industry has continued to improve its performance and is on its way to meeting these goals.

- Non-fatal injuries: the injury rate by 2005 was 6.3 injuries per 100 fulltime workers, approaching the target rate of 6.1 injuries per 100 fulltime workers.

- Fatal injuries: the fatal injury rate by 2005 was 11.1 per 100,000 workers, approaching the target rate of 10.2 fatal injuries per 100,000 workers.

While there is little question that these are positive signs of progress, and that the Construction Program has contributed to this improved safety and health performance, we do believe that a portion of the decline in the injury rate is likely due to under-reporting of injuries. This is an important issue and is discussed in more detail in section 4.1 of Chapter 3 of this report.

Judging progress on occupational illness and musculoskeletal disorders is more difficult to measure given limitations in national surveillance systems. Occupational illnesses, especially chronic illnesses, are known to be greatly underreported. The Program has worked to characterize the highest exposures for important construction health hazards such as silica, lead, and noise, and to develop interventions for high exposure tasks and operations to ready these hazards for guidance and regulation to drive wider risk management.

We can point to specific examples where we believe we have contributed to reduced exposures. For example, we anticipate that our engineering control work on the asphalt partnership will contribute to reduced exposures for an estimated 300,000 asphalt paving workers once the newer equipment with controls is completely phased in. Additionally, Program supported demonstration projects have shown that incorporating model lead specifications addressing comprehensive lead exposure precautions in construction contracts is an effective way to reliably reduce the incidence of elevated blood lead for workers de-leading and rehabilitating bridges. This has been shown in Connecticut, Michigan, and New Jersey.

The next chapter of this report describes activities, outputs, and outcomes of hundreds of projects conducted by the Center and the Construction Program over the last decade...All were (are) designed to contribute to health goals like these. Chapter three is designed to demonstrate our contribution to such all-important end outcomes. Chapter four describes our vision for the future of the program.

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